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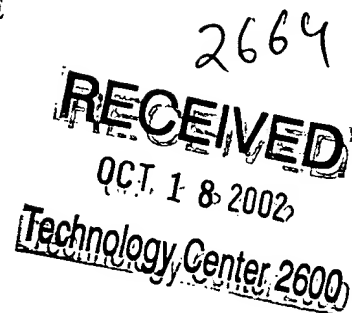
Appn. Number: 09/931,469

Filing Date: 08/16/2001

Assignee: Flarion Technologies, Inc.

Appl. Title: OFDM communications methods and apparatus

Art Unit: 2600

Examiner: NGUYEN, Steven

Mailed October 16, 2002

Boulder, CO 80303

Dear Sir,

The following prior-art references are submitted to the Examiner for consideration in the prosecution of Pat. Appl. No. 09/931,469, filed on 08/16/2001.

1. (Nassar et. al.) C. Nassar, B. Natarajan, S. Shattil, "Introduction of Carrier Interference to Spread Spectrum Multiple Access," Proceedings of the *IEEE Emerging Technologies Symposium on Wireless Communications and Systems*, Dallas, TX, April 12-13, 1999.

2. (Shattil01) S. Shattil, "Multiple Access Method and System," PCT Appl. No. PCT/US99/02838, International Publication No. WO 99/41871, 08/19/1999.

3. (Shattil02) S. Shattil, C. Nassar, "Array Control Systems for Multicarrier Protocols Using a Frequency-Shifted Feedback Cavity," Proceedings of the *1999 IEEE Radio and Wireless Conference*, Denver, CO, August 1-4, 1999.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., invalidate the independent patent claims, and thus, the dependent patent claims in Pat. Appl. No. 09/931,469.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., are printed publications that were available to the public more than one year before the priority date of

09/13/2000 claimed by Pat. Appl. No. 09/931,469, filed on 08/16/2001 as a Continuation-in-Part of Appl. No. 09/805,887, filed on 03/15/2001.

Furthermore, combinations of the prior-art references Shattil01, Shattil02, and Nassar et. al., are obvious combinations because they relate to multicarrier communications, and more specifically to Carrier Interference Multiple Access (CIMA) communications.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., describe methods and systems adapted to transmit and receive information-modulated pulse waveforms generated from a superposition of orthogonal carriers, as described and claimed in Pat. Appl. No. 09/931,469.

35 U.S.C. 102 Conditions for patentability; novelty and loss of right to patent.

A person shall be entitled to a patent unless -

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or

(e) the invention was described in-

(1) an application for patent, published under **section 122(b)**, by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in **section 351(a)** shall have the effect under this subsection of a national application published under **section 122(b)** only if the international application designating the United States was published under **Article 21(2)(a)** of such treaty in the English language.

The independent patent claims in Pat. Appl. No. 09/931,469 read on the prior-art references, Shattil01, Shattil02, and Nassar et. al. The prior-art references were available more than one year before priority date claimed by Pat. Appl. No. 09/931,469.

1. In independent Claim 1, a set of tones, or orthogonal carriers, being allocated to a user is described in Shattil01, such as on page 7, lines 27-29 and page 12, lines 23-28. The step of performing time domain to frequency domain conversion, as described in Claim 1, is performed by separating a time-domain signal into its frequency-domain components, or carriers, as described throughout Shattil01, such as on page 7, lines 4-6. The step of filtering the frequency-domain signal described in Claim 1 is described in Shattil01 with respect to filter 56 shown in FIG. 7. The step of performing frequency domain to time domain conversion recited in Claim 1 is described in Shattil01 with respect to combining the carriers (i.e., frequency-domain signals) to produce a time-domain signal (i.e., a summation, superposition, or composite signal 130), as illustrated in FIG. 4 and described throughout the specification, such as on page 6, lines 1-10 and on page 12, lines 12-14. The step of recovering symbols recited in Claim 1 is described in Shattil01, such as with respect to a decision step 66 in FIG. 7 and described on page 7, lines 10-13 and page 12, lines 12-14.

2. With respect to Claim 1, Nassar et. al. shows a receiver apparatus in Figure 5 having the same functionality. The function of the receiver shown in Nassar et. al. is described on page 3, column 2, lines 5-40. The receiver in Nassar et. al. is designed to receive multicarrier signals and also evaluate the bit-error-rate performance of the combination of steps described in Claim 1. In particular, the steps of performing time domain to frequency domain conversion and filtering the frequency-domain signal is achieved by projecting the received signal onto the orthonormal basis of the transmitted signals, as described on page 3, column 2, lines 13-19. Projecting a received multicarrier signal onto an orthonormal basis of a particular user's transmitted signal produces frequency-domain signal

components r = (r_0, r_1, ..., r_{N-1}) corresponding to that user's assigned carriers. Equivalently, the projection of a received signal onto an orthonormal basis excludes signals (e.g., carriers) that do not correspond to that orthonormal basis. Similarly, an array of bandpass filters, as described on page 3, column 2, lines 26-29 performs time domain to frequency domain conversion and frequency-domain filtering. The step of performing frequency domain to time domain conversion recited in Claim 1 is described in Nassar et. al. with respect to combining the received frequency-domain components produced by either bandpass filtering or projection onto an orthonormal basis of the transmitted signal. The combined frequency-domain components produce a time-domain signal, such as illustrated in Figures 1 and 2 and described on page 3, column 2, lines 20-40. The step of recovering symbols recited in Claim 1 is described in Nassar et. al. with respect to creating a decision variable, as described on page 3, column 2, lines 21-23, and on page 3, column 2, lines 30-40.

3. With respect to independent Claim 14, Shattil01 shows a receiver having substantially identical functionality as the receiver recited in Claim 14. A system in which a plurality of tones, or set of orthogonal carriers, is allocated to a user is described in Shattil01, such as on page 7, lines 27-29 and page 12, lines 23-28. A time domain to frequency domain transform module described in Claim 1, is described with respect to filter 56 in FIG. 7, which is adapted to separate a time-domain signal into its frequency-domain components, or carriers. The filter is described in Shattil01, such as on page 7, lines 4-6. The filter described in Shattil01 provides both time domain to frequency domain conversion and frequency-domain filtering. The frequency domain to time domain transform module recited in Claim 1 is described in Shattil01 with respect to combining the carriers (i.e., frequency-domain signals) to produce a time-domain signal (i.e., a summation, superposition, or composite signal 130), as illustrated in FIG. 4 and described throughout the specification, such as on page 6, lines 1-10 and on page 12, lines 12-14. Combiners 62m are illustrated in FIG. 7. A time instant to symbol mapping module recited in Claim 1 is described in Shattil01, such as with respect

to the plurality of delay elements (such as delay elements 60mn and 64m) and the decision module 66 shown in FIG. 7. Signal values at instants in time (i.e., phase spaces, or pulse positions centered at equally spaced time instants) are processed to generate estimated signal values, such as described in Shattil01 on page 7, lines 8-10 and page 15, lines 12-16. The function of a decision module includes mapping received signal values into estimated transmitted symbol values, and is described on page 7, lines 10-13 and page 12, lines 12-14.

4. With respect to Claim 14, Nassar et. al. shows a receiver apparatus in Figure 5 (which is described on page 3, column 2, lines 5-40) adapted to receive multicarrier signals and also evaluate the bit-error-rate performance of the functional implementation of a receiver that is described in Claim 1. In particular, the function of the time to frequency domain transform module and tone filter is achieved by a first software module shown in Figure 5 adapted to project the received signal onto the orthonormal basis of the transmitted signals. The first software module is illustrated by the set of multipliers adapted to multiply the received signal by reference signals having orthogonal carrier frequencies f_n and a predetermined phase relationship(s) $n\Delta\theta_k$, and a set of integrators adapted to integrate the products over each symbol interval. The function of the first module is described on page 3, column 2, lines 13-20. The outputs of the first module are frequency-domain signal components $r = (r_0, r_1, ..., r_{N-1})$ corresponding to a particular user's assigned carriers. Similarly, an array of bandpass filters, as described on page 3, column 2, lines 26-29 is a combined time to frequency domain transform module and tone filter. The frequency to time domain transform module recited in Claim 14 takes the form of a combiner shown in Figure 5 in Nassar et. al. The combined frequency-domain components produce a time-domain signal, such as illustrated in Figures 1 and 2, and described on page 3, column 2, lines 20-40. The time instant to symbol mapping module recited in Claim 1 is shown in Nassar et. al. with respect to a decision device following the combiner shown in Figure 5. The function of the decision device is described on page 3, column 2, lines 21-23 and on page 3, column 2, lines 30-40. The inclusion

of phase selection in the reference signals (such as described on page 2, column 1, lines 39-41) used in the multipliers of the first software module provides for selection of signal values at predetermined instants in time (i.e., pulse positions), such as shown in Figure 3 and described on page 2, column 1, line 20 to page 2, column 2, line 35.

5. With respect to independent Claim 20, Shattil01 describes a method of processing an orthogonal frequency division multiplexed signal (such as defined on page 4, lines 31-34) wherein channel equalization is performed (i.e., gain compensation is provided with respect to signal alterations due to channel effects, such as described on page 7, lines 6-7). The equivalence of equalization and compensation for channel effects is noted in (B. Sklar) B. Sklar, Digital Communications, P T R Prentice Hall, Upper Saddle River, New Jersey, 1988, pp. 104-105: "The process of thus correcting the channel-induced distortion is called *equalization.*" In Shattil01, channel equalization is followed by mapping values of the multicarrier signal at instants in time (i.e., phase spaces, or pulse positions centered at equally spaced instants in time, as shown in FIG. 4 and FIG. 12B) to information symbol values, such as described on page 7, lines 8-13.

Claim 20 specifies a step of performing channel equalization in the time domain, which is well known in the art and described in both Shattil01 and B. Sklar. In B. Sklar, page 105, line 1 to page 106, line 25, a transversal (i.e., time domain) filter consisting of a delay line with taps spaced at multiple symbol intervals provides a plurality of outputs that are summed and fed to a decision device. This transversal filter is shown in Figure 2.37. Tap coefficients are set to subtract the effects of interference from symbols that are adjacent in time to the desired symbol. Shattil01 shows the same transversal filter applied to the frequency-domain components in FIG. 7 and described on page 7, lines 8-13. In particular, each component is split into a number of delayed components by a plurality of delay elements 60mn. The delayed components are then combined in combiners 62m and then processed in a decision unit 66 that outputs estimates of the transmitted

information symbols. Furthermore, in Shattil01, page 8, lines 20-25, the receiver shown in FIG. 7 is adapted to sample signals in neighboring time intervals and combine the signals in the decision unit 66 (which is adapted to perform weight and sum) to cancel interference in the desired signal.

In fact, the use of time-domain equalizers in multicarrier receivers is described in many references that were published more than one year before the claimed priority date. For example, time-domain equalizers are shown in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996, and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

6. With respect to independent Claim 20, Nassar et. al. describes a method of processing an orthogonal frequency division multiplexed signal at a receiver including performing channel equalization in the form of any of various combining methods, such as described on page 3, column 2, lines 21-40. Combining is followed by mapping received signal values corresponding to each pulse (i.e., equally spaced instants in time used to transmit symbol values) into decision variables (i.e., estimated signal values).

The well-known technique of time-domain equalization is accomplished via frequency-domain combining. For example, the minimization of mean-squared distortion in the signal processed in a transversal filter (such as described in B. Sklar on page 106, lines 1-25) is accomplished in the frequency domain via optimal combining, such as minimum mean square error combining. Furthermore, in multipath environments, frequency domain combining leads to far superior performance than time-domain equalization by avoiding the problems of inter-symbol interference. Alternatively, time-domain equalization may be provided, as is well-known in the art (e.g., N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp.

56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992).

7. With respect to independent Claim 22, Shattil01 describes an apparatus (page 7, lines 3-14, and FIG. 7) for processing an orthogonal frequency division multiplexed signal (such as defined on page 4, lines 31-34) including a channel compensator (i.e., a channel-equalization module) and a combiner and decision module adapted to estimate the values of received signals impressed on individual pulses (i.e., instants in time used to transmit symbol values).

FIG. 7 in Shattil01 shows a well known time-domain equalizer known as a transversal filter. In B. Sklar, page 105, line 1 to page 106, line 25, a transversal (i.e., time domain) filter consisting of a delay line with taps spaced at multiple symbol intervals provides a plurality of outputs that are summed and fed to a decision device. This transversal filter is shown in Figure 2.37. Tap coefficients are set to subtract the effects of interference from symbols that are adjacent in time to the desired symbol. Shattil01 shows the same transversal filter applied to the frequency-domain components in FIG. 7 and described on page 7, lines 8-13. In particular, each component is split into a number of delayed components by a plurality of delay elements 60mn. The delayed components are then combined in combiners 62m and then processed in a decision unit 66 that outputs estimates of the transmitted information symbols. Furthermore, in Shattil01, page 8, lines 20-25, the receiver shown in FIG. 7 is adapted to sample signals in neighboring time intervals and combine the signals in the decision unit 66 (which is adapted to perform weight and sum) to cancel interference in the desired signal.

The implementation of a time-domain equalizer for channel compensation in a multicarrier receiver (such as described in both Shattil01 and U.S. Pat. Appl. No. 09/931,469) is an obvious combination. Furthermore, the use of time-domain equalizers in multicarrier receivers is well known. For example, time-domain

equalizers are described in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

8. With respect to independent Claim 22, Nassar et. al. describes a receiver (Figure 5, and page 3, column 2, lines 6-40) adapted to process orthogonal multicarrier (e.g., OFDM) signals. The receiver in Nassar et. al. includes a combiner adapted to optimally combine the carriers with respect to the channel model described on page 3, column 1, line 14 to page 3, column 2, line 4. Thus, the combiner is adapted to perform channel equalization. The combiner is followed by a decision device adapted to estimate the values of information signals modulated onto pulses (i.e., instants in time where the superposition of carriers produces a pulse conveying the information).

The implementation of a time-domain equalizer in Nassar et. al. is an obvious variation, since the use of time-domain equalizers in multicarrier receivers is well known. For example, time-domain equalizers are described in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

9. With respect to independent Claim 24, Shattil01 describes a communication system for processing an orthogonal frequency division multiplexed signal, such as defined on page 4, lines 31-34. The communication system includes a transmitter (such as illustrated in FIG. 1 and FIG. 2, and described throughout the document, such as on page 4, line 25 to page 6, line 12 and page 12, lines 3-28) adapted to impress information symbols onto pulses centered at uniformly spaced instants in time. The pulses are generated from a superposition of the orthogonal

multicarrier signals, which have a uniform frequency spacing f_s and repetition (i.e., symbol) period of $1/f_s$. The communication system described in Shattil01 also includes a receiver (such as illustrated in FIG. 7, and described on page 7, lines 3-14) adapted to estimate information symbols impressed on the received pulses.

10. With respect to independent Claim 24, Nassar et. al. describes a communication system for processing an orthogonal frequency division multiplexed signal. The communication system includes a transmitter (such as illustrated in Figure 4, and described on page 2, column 1, line 19 to page 3, column 1, line 13) and a receiver (such as illustrated in Figure 5, and described on page 3, column 2, lines 5-40). The transmitter maps data symbols onto CIMA envelopes (i.e., pulse waveforms generated from a superposition of the orthogonal carriers) that are positioned in time at equally spaced intervals. Each pulse has a pulse period, and thus, a corresponding equivalent symbol period T_b related to the carrier frequency spacing Δf, where $\Delta f = 1/T_b$. The receiver includes a decision device that is adapted to estimate the values of the transmitted data symbols impressed on the received pulses.

The dependent patent claims in Pat. Appl. No. 09/931,469 read on prior-art references Shattil01, Shattil02, and Nassar et. al., as well as other well known prior-art references dated more than one year before the priority claimed by 09/931,469.

All of the dependent claims in Pat. Appl. No. 09/931,469 read on prior-art references that were published more than one year before the claimed priority date.

Since these references all relate to the field of multicarrier transmission protocols and are authored by the same person, and the combinations of the independent and dependent claims do not contradict what is well known in the art, there are no non-obvious combinations of the independent and dependent claims.

1. With respect to dependent Claim 2, the step of performing channel equalization in Pat. Appl. No. 09/931,469 is also performed in Shattil01, Shattil02, and Nassar et. al. Specifically, Shattil01 describes channel compensation (page 7, lines 6-7) and also shows a time-domain equalizer in the form of a transversal filter (FIG. 7, page 7, lines 8-13, and page 8, lines 20-25). Nassar et. al. describes various combining methods (page 3, column 2, lines 30-40) used to compensate for fading channels, such as described on page 3, column 1, line 14 to page 3, column 2, line 4. In Shattil02 (page 4, column 1, lines 7-24), multipath fading on each orthogonal carrier is corrected after the channel distortions are characterized from known training symbols or adaptively via estimation algorithms.

   Performing channel equalization in an OFDM system is well known in the art. Many references, such as U.S. Pat. No. 5,867,478, disclose channel equalization techniques for processing OFDM signals. Time-domain equalizers used in multicarrier systems are also described in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

2. With respect to dependent Claim 3, channel estimation in an OFDM system is well known in the art and is typically regarded as a process included in channel equalization (i.e., channel compensation). For example, preset equalization (which uses a training sequence) and adaptive equalization (which relies on evaluating received channel errors), such as described in B. Sklar, page 106, lines 1-25, involve direct or indirect channel estimation. In U.S. Pat. No. 5,867,478, column 1, lines 14-41, a receiver compares received pilot symbols with known pilot symbol values to measure channel response. Shattil02 (page 4, column 1, lines 7-24) describes transmitting known training symbols on a set of orthogonal carriers to characterize fading on each carrier frequency. The receiver shown in Nassar et. al. processes known data symbols to generate combiner weights. For

example, a typical equal-gain combining algorithm uses known and/or constant-modulus transmission symbol values to perform equalization.

3. With respect to dependent Claims 4 through 9, many references, such as U.S. Pat. No. 5,867,478, column 1, lines 14-41, describe processing received OFDM signals preceded by performing channel estimation in which pilot symbols are spaced in time and frequency according to the expected rate of channel variation in time and frequency, respectively. Shattil02 (page 4, column 1, lines 7-24) also describes transmitting known training symbols on a set of orthogonal carriers to characterize fading on each carrier frequency.

4. With respect to dependent Claim 10, Shattil01 describes a receiver (such as illustrated in FIG. 7 and described on page 7, lines 3-23) adapted to estimate information symbols impressed on received pulses. The pulses are centered at equally spaced instants in time used to transmit symbol values. Similarly, Nassar et. al. describes a receiver (such as illustrated in Figure 5, and described on page 3, column 2, lines 5-40) adapted to estimate data symbols modulated on CIMA pulses centered at equally spaced instants in time.

5. With respect to dependent Claim 11, methods of formatting information symbols, such as mapping a constellation of data symbols to a constellation of modulation levels, and the reverse operation, are well known in the art and are typically understood to be a process within a symbol estimation or decision step. For example, B. Sklar (Figure 2.2 and page 54, lines 3-22) describes signal formatting in which information symbols are converted to waveform symbols at a transmitter and the reverse conversion is performed at a receiver.

U.S. Pat. No. 5,363,408 describes prior-art techniques for mapping a plurality of data bits into a constellation of modulation levels, such as on column 1, lines 20-44. U.S. Pat. No. 5,384,810 describes a decoder adapted to perform symbol-to-bit mapping, such as on column 5, lines 51-54. In U.S. Pat. No. 5,455,839, digital

data is mapped into a signal point sequence with respect to a predetermined code. Inverse mapping produces an estimated data sequence from a received signal point sequence (column 3, lines 20-37). An inverse mapping device produces an estimated data sequence from a received signal point sequence (column 8, line 5 to column 9, line 4).

6. With respect to dependent Claim 12, time domain to frequency domain processes and frequency domain to time domain processes are commonly performed using Fourier transforms or Cosine transforms. For example, U.S. Pat. No. 5,815,488 ("Multiple user access method using OFDM," September 29, 1998, column 10, lines 37-40) describes the use of Fourier transforms and cosine transforms in OFDM transmitters and receivers. U.S. Pat. No. 5,933,421 shows an inverse discreet Fourier transform unit in an OFDM transmitter (such as in FIGs. 1.7, 1.12, and 1.13) and a discreet Fourier transform unit in an OFDM receiver (such as in FIGs. 1.15, 1.16, and 2.2). U.S. Pat. No. 5,371,761 shows an inverse fast Fourier transform unit in a transmitter (FIG. 4) and a fast Fourier transform unit in a receiver (FIGs. 5, 7, and 8).

7. With respect to dependent Claim 13, Shattil01 describes a multicarrier communication system adapted to process signals from multiple users, such as on page 7, lines 27-29, page 8, lines 20-25, page 12, lines 3-14, and page 12, lines 23-28. Similarly, other references, such as U.S. Pat. No. 5,815,488, describe frequency division multiple access in OFDM.

8. With respect to dependent Claim 15, a channel equalization module (e.g., a channel compensator or an optimal combiner) in a multicarrier receiver is described in both Shattil01 and Nassar et. al. Specifically, Shattil01 describes channel compensation (page 7, lines 6-7) and Nassar et. al. describes various combining methods (page 3, column 2, lines 30-40) that may be used to compensate for fading channels, such as described on page 3, column 1, line 14 to page 3, column 2, line 4. Performing channel equalization in an OFDM system is

well known in the art. Many references, such as U.S. Pat. No. 5,867,478, describe channel equalizers for use in processing received OFDM signals.

9. With respect to dependent Claim 16, a channel estimation circuit in an OFDM system is well known in the art and is typically regarded as a part of a channel equalizer (i.e., a channel compensator). For example, preset equalization (which uses a training sequence) and adaptive equalization (which relies on evaluating received channel errors), such as described in B. Sklar, page 106, lines 1-25, involve direct or indirect channel estimation. Shattil02 (page 4, column 1, lines 7-24) describes transmitting known training symbols on a set of orthogonal carriers to characterize fading on each carrier frequency. Similarly, adaptive techniques, or estimation algorithms may be used. In U.S. Pat. No. 5,867,478, column 1, lines 14-41, a receiver compares received pilot symbols with known pilot symbols to measure channel response. Time-domain equalizers are also described in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

10. With respect to dependent Claim 17, formatting information symbols, such as mapping a constellation of data symbols to a constellation of modulation levels, and the reverse operation, are well known in the art. For example, B. Sklar (Figure 2.2 and page 54, lines 3-22) describes signal formatting in which information symbols are converted to waveform symbols at a transmitter and the reverse conversion is performed at a receiver.

U.S. Pat. No. 5,363,408 describes prior-art techniques for mapping a plurality of data bits into a constellation of modulation levels, such as on column 1, lines 20-44. U.S. Pat. No. 5,384,810 describes a decoder adapted to perform symbol-to-bit mapping, such as on column 5, lines 51-54. In U.S. Pat. No. 5,455,839, digital data is mapped into a signal point sequence with respect to a predetermined code.

Inverse mapping produces an estimated data sequence from a received signal point sequence (column 3, lines 20-37). An inverse mapping device produces an estimated data sequence from a received signal point sequence (column 8, line 5 to column 9, line 4).

11. With respect to dependent Claim 18, many references, such as U.S. Pat. No. 5,732,113, column 4, lines 26-44, describe receivers adapted to discard cyclic prefixes used in multicarrier signals.

12. With respect to dependent Claim 19, it is well known in the art relating to multicarrier processing, such as OFDM, that a Fourier transform (e.g., a fast Fourier transform) may be used to perform a time domain to frequency domain transform. Similarly, it is well known in the art relating to OFDM that an inverse Fourier transform (e.g., an inverse fast Fourier transform) may be used to perform a frequency domain to time domain transform. For example, U.S. Pat. No. 5,371,761 shows a fast Fourier transform implemented in an OFDM receiver (FIG. 5, column 4, line 50 to column 5, line 12) adapted to convert a time domain signal to a frequency domain signal, and an inverse fast Fourier transform in an OFDM transmitter (FIG. 4, column 4, lines 7-49) adapted to convert frequency domain signals into time domain signals. U.S. Pat. No. 5,933,421 shows an inverse discreet Fourier transform unit in an OFDM transmitter (such as in FIGs. 1.7, 1.12, and 1.13) and a discreet Fourier transform unit in an OFDM receiver (such as in FIGs. 1.15, 1.16, and 2.2). U.S. Pat. No. 5,371,761 shows an inverse fast Fourier transform unit in a transmitter (FIG. 4) and a fast Fourier transform unit in a receiver (FIGs. 5, 7, and 8).

13. With respect to dependent Claim 21, Shattil01 describes using a frequency filter (page 7, lines 4-6) to select carriers allocated to a particular user. The filter may provide for separating users with respect to different sets of orthogonal carrier frequencies (page 7, lines 27-29). Shattil02 shows a filter bank (Figure 6) for selecting a predetermined set of carrier frequencies. Nassar et. al. shows that

frequency-domain filtering is achieved by projecting the received signal onto the orthonormal basis of the transmitted signals, as described on page 3, column 2, lines 13-19. Projecting a received multicarrier signal onto an orthonormal basis of a particular user's transmitted signal produces frequency-domain signal components $r = (r_0, r_1, ..., r_{N-1})$ corresponding to that user's assigned carriers. Similarly, Nassar et. al. mentions using an array of bandpass filters (described on page 3, column 2, lines 26-29) to separate a CIMA signal into its component carrier frequencies.

Assignment of different sets of carrier frequencies to different users in an OFDM system is a well-known multiple-access technique. For example, U.S. Pat. No. 5,933,421 (column 5, lines 9-38) describes frequency-division duplexing to allow multiple users in an OFDM system to communicate within a given time interval via use of different sets of OFDM subcarriers. A set of tones for a particular traffic channel are selected by a demultiplexer, such as shown with respect to FIG. 1.10, column 16, lines 2-4.

In each case, the use of a filter or demultiplexer to select a given set of carriers is equivalent to deselecting, or filtering out, signals that are not in the given carrier set.

14. With respect to dependent Claim 23, Shattil01 describes a frequency-domain filter (page 7, lines 4-7) adapted to separate a received time domain signal (such as a superposition of carriers shown in FIG. 4) into its frequency-domain components (i.e., component carriers). The filter selects carriers allocated to a particular user or group of users, such as described on page 7, lines 27-29, and on page 7, line 33 to page 8, line 7. Shattil01 also shows a time-domain equalizer in the form of a transversal filter (FIG. 7, page 7, lines 8-13, and page 8, lines 20-25). The frequency-domain components are converted back to a superposition, or time-domain signal, by combining (page 7, lines 9-13) the components.

Nassar et. al describes a multicarrier receiver adapted to project received time-domain signals onto an orthonormal basis of a transmitted signal, such as shown in Figure 5 and described on page 3, column 2, lines 13-20. Thus, the receiver in Nassar et. al. converts a received time-domain signal (such as shown in Figures 1, 2, and 3) into its frequency-domain components and filters those components to select only those signal components corresponding to a particular user's transmission. Projecting received signals onto an orthonormal basis corresponding to transmissions intended for a particular user filters, or excludes, signals not allocated to that particular user. For example, a plurality of bandpass filters is described on page 7, line 26. Alternatively, a matched filter is disclosed on page 7, lines 26-29. The frequency-domain signals are then combined (page 3, column 2, lines 21-23 and page 3, column 2, lines 30-40) to estimate data symbols impressed on the transmitted pulses (i.e., time-domain signals).

Shattil02 shows a filter bank (Figure 5) adapted to separate a received signal corresponding to a particular user into its frequency components followed by a summing circuit adapted to combine the frequency components to reconstruct the received signal corresponding to the user, as described on page 3, column 1, line 9 to page 4, column 1, line 5.

15. The components described in dependent Claim 25 are provided in Shattil01, Nassar et. al., and Shattil02, as described with respect to Claim 23.

16. With respect to claim 26, Shattil01 describes channel compensation circuits (i.e., equalizers) adapted to perform gain adjustments to individual frequency components to correct for channel distortions, such as described on page 7, lines 6-7. The compensators follow a frequency-domain filter adapted to select and separate a received signal into its frequency-domain components. The compensators precede a combining circuit adapted to combine the equalized frequency components to produce a time-domain signal, such as one or more

pulses or estimated data symbols modulated onto pulses centered at equally spaced instants in time.

FIG. 7 in Shattil01 also shows a well known time-domain equalizer known as a transversal filter. In B. Sklar, page 105, line 1 to page 106, line 25, a transversal (i.e., time domain) filter consisting of a delay line with taps spaced at multiple symbol intervals provides a plurality of outputs that are summed and fed to a decision device. Tap coefficients are set to subtract the effects of interference from symbols that are adjacent in time to the desired symbol. Shattil01 shows the same transversal filter applied to the frequency-domain components in FIG. 7 and described on page 7, lines 8-13. In particular, each component is split into a number of delayed components by a plurality of delay elements 60mn. The delayed components are then combined in combiners 62m and then processed in a decision unit 66 that outputs estimates of the transmitted information symbols. Furthermore, in Shattil01, page 8, lines 20-25, the receiver shown in FIG. 7 is adapted to sample signals in neighboring time intervals and combine the signals in the decision unit 66 (which is adapted to perform weight and sum) to cancel interference in the desired signal.
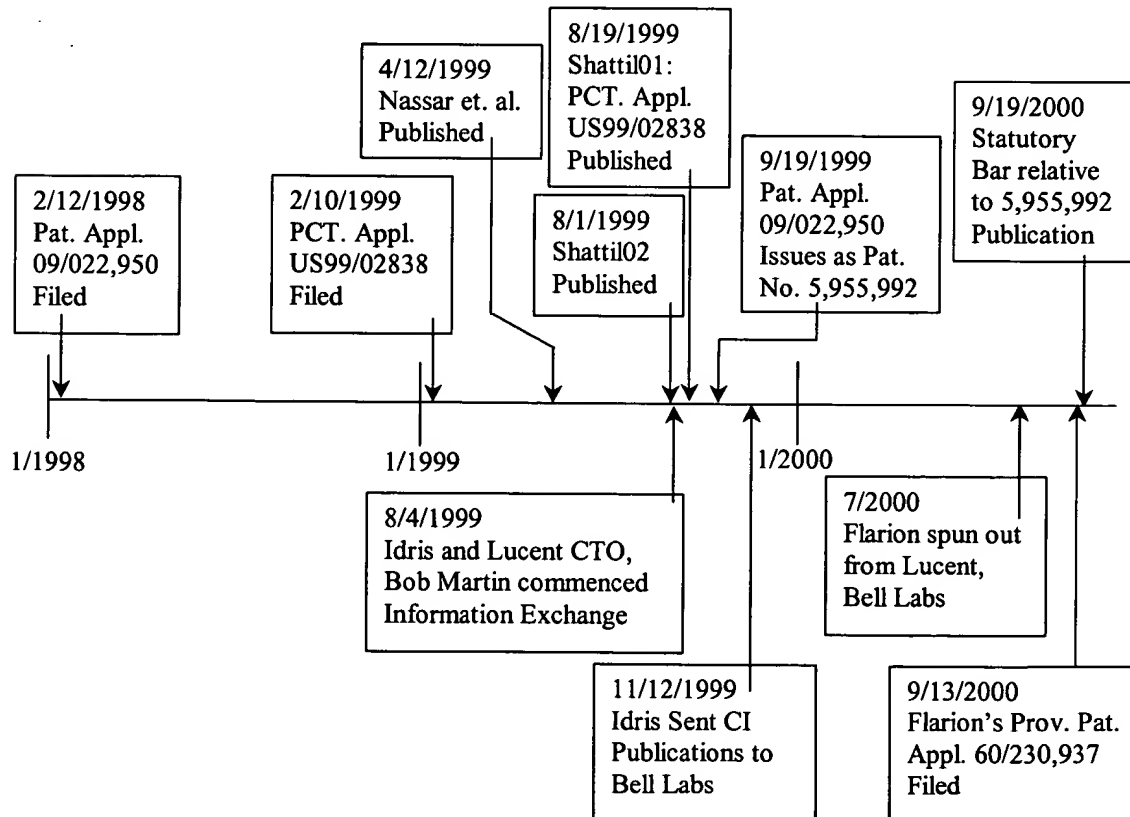
Nassar et. al. describes a receiver that includes a channel equalization module in the form of any of various combining algorithms, such as described on page 3, column 2, lines 21-40. The combiner is followed by a decision circuit that maps received signal values corresponding to each pulse (i.e., instants in time used to transmit symbol values) into decision variables (i.e., estimated signal values).

Time domain channel equalizers are well known in the field of multicarrier receivers, and in particular, OFDM receivers. For example, time-domain equalizers are shown in N. Al-Dhahir and J.M. Cioffi, "Optimum Finite Length Equalization for Multicarrier Transceivers," *IEEE Trans. on Comm.*, pp. 56-64, January 1996 and J.S. Chow and J.M. Cioffi, "A cost-effective maximum

likelihood receiver for multicarrier systems," *Proc. IEEE Int. Conf. On Comm.*, pp. 948-952, June 1992.

The invention described in Pat. Appl. No. 09/931,469, assigned to Flarion Technologies, is similar to technologies disclosed by Idris Communications, Inc. to Lucent and Bell Laboratories prior to Lucent spinning off Flarion Technologies, and more than one year prior to the priority date claimed by Pat. Appl. No. 09/931,469.

The following timeline summarizes relevant filing and publication dates establishing priority dates and statutory bar dates. Also included in the timeline are dates establishing the period of information exchange between Idris Communications, Inc. and Lucent/Bell Labs, and the spin off of Flarion Technologies, Inc. from Lucent. As illustrated by the time line, the filing of Provisional Pat. Appl. No. 60/230,937 may have been made to avoid a statutory bar resulting from the publication of U.S. Pat. No. 5,955,992.

- 2/12/1998 Pat. Appl. 09/022,950 Filed
- 2/10/1999 PCT. Appl. US99/02838 Filed
- 4/12/1999 Nassar et. al. Published
- 8/19/1999 Shattil01: PCT. Appl. US99/02838 Published
- 8/1/1999 Shattil02 Published
- 9/19/1999 Pat. Appl. 09/022,950 Issues as Pat. No. 5,955,992
- 9/19/2000 Statutory Bar relative to 5,955,992 Publication
- 8/4/1999 Idris and Lucent CTO, Bob Martin commenced Information Exchange
- 7/2000 Flarion spun out from Lucent, Bell Labs
- 11/12/1999 Idris Sent CI Publications to Bell Labs
- 9/13/2000 Flarion's Prov. Pat. Appl. 60/230,937 Filed

1/1998   1/1999   1/2000

The following information about the information exchange between Idris Communications, Inc. and Lucent/Bell Labs prior to Lucent Bell Labs spinning of Flarion Technologies is provided here as a matter of record. Idris Communications is a licensee of U.S. Pat. No. 5,955,992 and PCT Appl. No. PCT/US99/02838. Arnold Alagar, Chief Operating Officer of Idris Communications, met Robert Martin, Chief Technology Officer of Lucent Technologies, at the Disruptive Innovations Conference in Memphis Tennessee in July, 1999.

Lucent and Idris Communications continued conversations to explore establishing a business partnership to commercialize technologies being developed by Idris, including Carrier Interferometry. Information exchanges between Idris and Lucent included Idris supplying Lucent with copies of papers published at conferences on Carrier Interferometry, papers published on the Idris website, and issued U.S. patents (including U.S. Pat. No. 5,995,992). No dates of publication were indicated on the papers published at conferences. Information exchanges also included telephone calls and teleconferences with Robert Martin, Paul Mankiewich, and other Lucent/Bell Labs staff members.
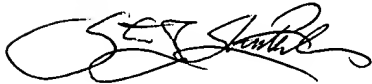
Robert Martin also stated via e-mail that he would pass our information to other people in Bell Laboratory's wireless department. Lucent's final communication with Idris was on December 31, 1999, in which Paul Mankiewich stated that he would contact Mr. Alagar the following week in regard to evaluating the relationship between Lucent and Idris. Paul Mankiewich never contacted Mr. Alagar after December 31, 1999, and Lucent did not respond to attempts by Idris Communications to make contact in January 2000. On July 24, 2000, Lucent publicized that it had spun off Flarion Technologies in the second quarter of 2000 to commercialize a seemingly unrelated technology, called "Flash OFDM," based on fast frequency hopping. On September 13, 2000, Flarion filed a provisional patent application (Pat. Appl. No. 60/230,937) claiming similar "innovations" disclosed to Lucent/Bell Labs by Idris Communications. Flarion's filing date indicates the possible awareness of U.S. Pat. No. 5,955,992 since their filing date avoids a statutory bar with respect to the publication of U.S. Pat. No. 5,955,992 by only six days.

Considering the following facts:

- Lucent's Chief Technology Officer received documents describing the subject technology from Idris Communications Inc.
- Documents describing this technology being developed by Idris Communications were passed to Bell Laboratory's wireless group.
- Rajiv Laroia, an inventor cited on Pat. Appl. No. 09/931,469, held the position of Head of Bell Labs' Digital Communications Research Department in the Wireless Research Center.

It is probable that the inventors cited in Pat. Appl. No. 09/931,469 signed the Oath and Declaration claiming to have invented the subject matter disclosed in Pat. Appl. No. 09/931,469 with the knowledge of U.S. Pat. No. 5,955,992, and other publications provided by Idris Communications.

Very Respectfully,

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